

CLAIMS

What is claimed is:

Claims 1-109 (cancelled)

- 5 110. (previously presented): A network having a plurality of multicast connections, said network comprising:

an input stage comprising  $r_1$  input switches, and  $n_1$  inlet links for each of said  $r_1$  input switches;

- 10 an output stage comprising  $r_2$  output switches, and  $n_2$  outlet links for each of said  $r_2$  output switches; and

- a middle stage comprising  $m$  middle switches, and each middle switch comprising at least one link (hereinafter "first internal link") connected to each input switch for a total of at least  $r_1$  first internal links, each middle switch further comprising at least one link (hereinafter "second internal link") connected to each output switch for a  
15 total of at least  $r_2$  second internal links;

said network further is always capable of setting up said multicast connection by never changing path of an existing multicast connection, and the network is hereinafter "strictly nonblocking network", where  $m$  is a minimum of at least  $2 * n_1 + n_2 - 1$ .

- 20 111. (previously presented): The network of claim 110 wherein each multicast connection from an inlet link passes through at most two middle switches, and said multicast connection further passes to a plurality of outlet links from said at most two middle switches.

- 25 112. (previously presented): The network of claim 110 further comprising a controller coupled to each of said input, output and middle stages to set up said multicast connection.

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113. (previously presented): The network of claim 110 wherein said  $r_1$  input switches and  $r_2$  output switches are the same number of switches.

114. (previously presented): The network of claim 110 wherein said  $n_1$  inlet links and  $n_2$  outlet links are the same number of links and  $n_1 = n_2 = n$ , then  $m$  is a minimum of at least  $3 * n - 1$ .

115. (previously presented): The network of claim 110, wherein each of said input switches, or each of said output switches, or each of said middle switches further recursively comprise one or more networks.

116. (previously presented): A method for setting up one or more multicast connections in a network having an input stage having  $n_1 * r_1$  inlet links and  $r_1$  input switches, an output stage having  $n_2 * r_2$  outlet links and  $r_2$  output switches, and a middle stage having  $m$  middle switches, where each middle switch is connected to each of said  $r_1$  input switches through  $r_1$  first internal links and each middle switch further comprising at least one link connected to at most  $d$  said output switches for a total of at least  $d$  second internal links, wherein  $1 \leq d \leq r_2$ , said method comprising:

receiving a multicast connection at said input stage;

fanning out said multicast connection in said input stage into at most two middle switches to set up said multicast connection to a plurality of output switches among said  $r_2$  output switches, wherein said plurality of output switches are specified as destinations of said multicast connection, wherein first internal links from said input switch to said at most two middle switches and second internal links to said destinations from said at most two middle switches are available;

wherein said act of fanning out is performed without changing any existing connection to pass through another middle switch.

117. (previously presented): The method of claim 116 wherein said act of fanning out is performed recursively.

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118. (previously presented): A method for setting up one or more multicast connections in a network having an input stage having  $n_1 * r_1$  inlet links and  $r_1$  input switches, an output stage having  $n_2 * r_2$  outlet links and  $r_2$  output switches, and a middle stage having  $m$  middle switches, where each middle switch is connected to each of said  $r_1$  input switches through  $r_1$  first internal links and each middle switch further comprising at least one link connected to at most  $d$  said output switches for a total of at least  $d$  second internal links, wherein  $1 \leq d \leq r_2$ , said method comprising:

checking if at least a first subset of destination output switches of said multicast connection have available second internal links to a first middle switch; and  
10 checking if a second middle switch has available second internal links to a second subset of destination output switches of said multicast connection.

wherein each destination output switch of said multicast connection is one of said first subset of destination output switches and said second subset of destination output switches.

119. (previously presented): The method of claim 118 further comprising:  
checking if the input switch of said multicast connection has an available first internal link to said first middle switch and to said second middle switch.

120. (previously presented): The method of claim 118 further comprising:  
prior to said checkings, checking if all the destination output switches of said  
20 multicast connection are available at said first middle switch.

121. (previously presented): The method of claim 118 further comprising:  
repeating said checkings of available second internal links to another second subset of destination output switches for each middle switch other than said first and said second middle switches.

25 wherein each destination output switch of said multicast connection is one of said first subset of destination output switches and said second subset of destination output switches.

122. (previously presented): The method of claim 118 further comprising:

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repeating said checkings of available second internal links to another first subset of destination output switches with each middle stage switch other than said first middle stage switch.

123. (previously presented): The method of claim 118 further comprising:

- 5       repeating said checkings of available first internal link to each middle stage switch other than said first middle switch and said second middle switch.

124. (previously presented): The method of claim 118 further comprising:

- setting up each of said multicast connection from its said input switch to its said output switches through not more than two middle switches, selected by said checkings,  
10   by fanning out said multicast connection in its said input switch into not more than said two middle stage switches.

125. (previously presented): The method of claim 118 wherein any of said acts of checking and setting up are performed recursively.

126. (cancelled)

15   127. (cancelled)

128. (cancelled)

129. (cancelled)

130. (cancelled)

20   131. (previously presented): A network having a plurality of multicast connections, said network comprising:

      an input stage comprising  $r_1$  input switches and  $n_1$  inlet links for each of said  $r_1$  input switches, and  $N_1 = n_1 * r_1$ ;

      an output stage comprising  $r_2$  output switches and  $n_2$  outlet links for each of said  $r_2$  output switches, and  $N_2 = n_2 * r_2$ ; and

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a middle stage comprising  $m$  middle switches, and each middle switch comprising at least one link connected to each input switch for a total of at least  $r_1$  first internal links; each middle switch further comprising at least one link connected to each output switch for a total of at least  $r_2$  second internal links,

- 5        said network further is always capable of setting up said multicast connection by never changing path of an existing multicast connection, and the network is hereinafter “strictly nonblocking network”, where  $m$  is a minimum of at least  $3 * n_1 + n_2 - 1$ .

132. (previously presented): The network of claim 131 wherein each multicast connection from an inlet link passes through at most three middle switches, and said  
10    multicast connection further passes to a plurality of outlet links from said at most three middle switches.

133. (previously presented): The network of claim 131 comprising a controller in communication with said input, output and middle stages to set up said multicast connection.

- 15    134. (previously presented): The network of claim 131 wherein said  $r_1$  input switches and  $r_2$  output switches are the same number of switches.

135. (previously presented): The network of claim 131 wherein said  $n_1$  inlet links and  $n_2$  outlet links are the same number of links and  $n_1 = n_2 = n$ , then  $m$  is a minimum of at least  $4 * n - 1$ .

- 20    136. (previously presented): The network of claim 131,  
      wherein each of said input switches, or each of said output switches, or each of said middle switches further recursively comprise one or more networks.

137. (previously presented): A method for setting up one or more multicast connections in a network having an input stage having  $n_1 * r_1$  inlet links and  $r_1$  input switches, an  
25    output stage having  $n_2 * r_2$  outlet links and  $r_2$  output switches, and a middle stage

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having  $m$  middle switches, where each middle switch is connected to each of said  $r_1$  input switches through  $r_1$  first internal links and each middle switch further comprising at least one link connected to at most  $d$  said output switches for a total of at least  $d$  second internal links, wherein  $1 \leq d \leq r_2$ , said method comprising :

5 receiving a multicast connection at said input stage;

fanning out said multicast connection in said input stage into at most three middle switches to set up said multicast connection to a plurality of output switches among said  $r_2$  output switches of said multicast connection, wherein said plurality of output switches are specified as destinations of said multicast connection, wherein first internal links from  
10 said input switch to said at most three middle switches and second internal links to said destinations from said at most three middle switches are available,

wherein said act of fanning out is performed without changing any existing connection to pass through another middle switch.

138. (previously presented): The method of claim 137 wherein said act of fanning out is  
15 performed recursively.

139. (previously presented): A method for setting up one or more multicast connections in a network having an input stage having  $n_1 * r_1$  inlet links and  $r_1$  input switches, an output stage having  $n_2 * r_2$  outlet links and  $r_2$  output switches, and a middle stage having  $m$  middle switches, where each middle switch is connected to each of said  $r_1$   
20 input switches through  $r_1$  first internal links and each middle switch further comprising at least one link connected to at most  $d$  said output switches for a total of at least  $d$  second internal links, wherein  $1 \leq d \leq r_2$ , said method comprising :

checking if all the destination output switches of said multicast connection have available second internal links from at most three middle switches.

25 140. (previously presented): The method of claim 139 further comprising:

checking if the input switch of said multicast connection has available first internal links to at most said three middle switches.

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141. (previously presented): The method of claim 139 further comprising:  
repeating said checkings of available second internal links to all said destination output switches for all the other combinations of at most three middle switches.
142. (previously presented): The method of claim 139 further comprising:  
5 repeating said checkings of available first internal links for all the other combinations of at most three middle switches.
143. (previously presented): The method of claim 139 further comprising:  
setting up each of said connection from its said input switch to its said output switches through at most said three middle switches, selected by said checkings, by  
10 fanning out said multicast connection in its said input switch into at most said three middle stage switches;
144. (previously presented): The method of claim 139 wherein any of said acts of checking and setting up are performed recursively.
145. (cancelled)
- 15 146. (cancelled)
147. (cancelled)
148. (cancelled)
149. (cancelled)
150. (previously presented): A network having a plurality of multicast connections, said  
20 network comprising:  
an input stage comprising  $r_1$  input switches and  $n_1$  inlet links for each of said  $r_1$  input switches, and  $N_1 = n_1 * r_1$ ;  
an output stage comprising  $r_2$  output switches and  $n_2$  outlet links for each of said  $r_2$  output switches, and  $N_2 = n_2 * r_2$ ; and

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a middle stage comprising  $m$  middle switches, and each middle switch comprising at least one link connected to each input switch for a total of at least  $r_1$  first internal links; each middle switch further comprising at least one link connected to each output switch for a total of at least  $r_2$  second internal links, for  $x \geq 1$ ,

- 5        said network further is always capable of setting up said connection by never changing path of a previously set up multicast connection, and the network is hereinafter “strictly nonblocking network”, where  $m \geq x * n_1 + n_2 - 1$ , for  $x \geq 2$ .

151. (previously presented): The network of claim 150 wherein each multicast connection from an inlet link passes through at most  $x$  middle switches, and said  
10        multicast connection further passes to a plurality of outlet links from said at most  $x$  middle switches.

152. (previously presented): The network of claim 150 comprising a controller in communication with said input, output and middle stages to set up said multicast connection.

- 15        153. (previously presented): The network of claim 150 wherein said  $r_1$  input switches and  $r_2$  output switches are the same number of switches.

154. (previously presented): The network of claim 150 wherein said  $n_1$  inlet links and  $n_2$  outlet links are the same number of links and  $n_1 = n_2 = n$ , then  $m \geq (x + 1) * n - 1$ .

155. (previously presented): The network of claim 150,  
20        wherein each of said input switches, or each of said output switches, or each of said middle switches further recursively comprise one or more networks.

156. (previously presented): A method for setting up one or more multicast connections in a network having an input stage having  $n_1 * r_1$  inlet links and  $r_1$  input switches, an output stage having  $n_2 * r_2$  outlet links and  $r_2$  output switches, and a middle stage  
25        having  $m$  middle switches, where each middle switch is connected to each of said  $r_1$

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input switches through  $r_1$  first internal links and each middle switch further comprising at least one link connected to at most  $d$  said output switches for a total of at least  $d$  second internal links, wherein  $1 \leq d \leq r_2$ , for  $x \geq 2$ , said method comprising:

receiving a multicast connection at said input stage;

- 5 fanning out said multicast connection in said input stage into at most  $x$  middle switches to set up said multicast connection to a plurality of output switches among said  $r_2$  output switches, wherein said plurality of output switches are specified as destinations of said multicast connection, wherein first internal links from said input switch to said at most  $x$  middle switches and second internal links to said destinations from said at most  $x$  middle switches are available,
- 10

wherein said act of fanning out is performed without changing any existing connection to pass through another middle switch.

157. (previously presented): The method of claim 156 wherein said act of fanning out is performed recursively.

- 15 158. (previously presented): A method for setting up one or more multicast connections in a network having an input stage having  $n_1 * r_1$  inlet links and  $r_1$  input switches, an output stage having  $n_2 * r_2$  outlet links and  $r_2$  output switches, and a middle stage having  $m$  middle switches, where each middle switch is connected to each of said  $r_1$  input switches through  $r_1$  first internal links and each of said  $r_2$  said output switches through  $r_2$  second internal links, for  $x \geq 2$ , said method comprising:
- 20

checking if all the destination output switches of said multicast connection have available second internal links from at most  $x$  middle switches.

159. (previously presented): The method of claim 158 further comprising:

- checking if the input switch of said multicast connection has an available first  
25 internal links to said at most  $x$  middle switches.

160. (previously presented): The method of claim 158 further comprising:

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repeating said checkings of available second internal links to all said destination output switches for all the other combinations of at most  $x$  middle switches.

161. (previously presented): The method of claim 158 further comprising:

5 repeating said checkings of available first internal links for all the other combinations of at most  $x$  middle switches.

162. (previously presented): The method of claim 158 further comprising:

10 setting up each of said connection from its said input switch to its said output switches through at most  $x$  said middle switches, selected by said checkings, by fanning out said multicast connection in its said input switch into at most said  $x$  middle stage switches.

163. (previously presented): The method of claim 158 wherein any of said acts of checking and setting up are performed recursively.

164. (cancelled)

165. (cancelled)

15 166. (cancelled)

167. (cancelled)

168. (cancelled)

169. (previously presented): A network having a plurality of multicast connections, said network comprising:

20 an input stage comprising  $r_1$  input switches and  $n_1$  inlet links for each of said  $r_1$  input switches, and  $N_1 = n_1 * r_1$ ;

an output stage comprising  $r_2$  output switches and  $n_2$  outlet links for each of said  $r_2$  output switches, and  $N_2 = n_2 * r_2$ ; and

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a middle stage comprising  $m$  middle switches, and each middle switch comprising at least one link connected to each input switch for a total of at least  $r_1$  first internal links; each middle switch further comprising at least one link connected to at most  $d$  said output switches for a total of at least  $d$  second internal links, wherein

5  $1 \leq d \leq r_2$  ,

wherein  $m \geq \sum_{i=1}^p (x_i * a_i + n_1 - 1)$  , where  $\sum_{i=1}^p a_i = n_1 + n_2$  and  $x_1, x_2, \dots, x_p \geq 1$  ;

wherein, for  $1 \leq i \leq p$  , multicast connections from  $a_i$  inlet links of each input switch pass through at most  $x_i$  middle switches,

said network further is capable of setting up said connection by never changing

10 path of a previously set up multicast connection, and the network is hereinafter “strictly nonblocking network”, where  $x_1, x_2, \dots, x_p \geq 2$  .

170. (previously presented): The network of claim 169 comprising a controller in communication with said input, output and middle stages to set up said multicast connection.

15 171. (previously presented): The network of claim 169 wherein said  $r_1$  input switches and  $r_2$  output switches are the same number of switches.

172. (previously presented): The network of claim 169 wherein said  $n_1$  inlet links and  $n_2$  outlet links are the same number of links and  $n_1 = n_2 = n$  .

173. (previously presented): The network of claim 169,

20 wherein each of said input switches, or each of said output switches, or each of said middle switches further recursively comprise one or more networks.

174. (previously presented): A network having a plurality of multicast connections, said network comprising:

an input stage comprising  $r_1$  input switches and  $n_1$  inlet links for each of said  $r_1$

25 input switches, and  $N_1 = n_1 * r_1$  ;

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an output stage comprising  $r_2$  output switches and  $n_2$  outlet links for each of said  $r_2$  output switches, and  $N_2 = n_2 * r_2$ ; and

a middle stage comprising  $m$  middle switches, and each middle switch comprising at least one link connected to each input switch for a total of at least  $r_1$  first  
5 internal links; each middle switch further comprising at least one link connected to at most  $d$  said output switches for a total of at least  $d$  second internal links, wherein  
10  $1 \leq d \leq r_2$ ,

said network further is always capable of setting up said connection by never changing path of a previously set up multicast connection, and the network is hereinafter  
15 “strictly nonblocking network”, where  $m$  is a minimum of at least  $2 * n_1 + n_2 - 1$ .

175. (previously presented): The network of claim 174 wherein each multicast connection from an inlet link passes through at most one or two middle switches, and said multicast connection further passes a plurality of outlet links from said at most two middle switches.

15 176. (previously presented): The network of claim 174 comprising a controller in communication with said input, output and middle stages to set up said multicast connection.

177. (previously presented): The network of claim 174 wherein said  $r_1$  input switches and  $r_2$  output switches are the same number of switches.

20 178. (previously presented): The network of claim 174 wherein said  $n_1$  inlet links and  $n_2$  outlet links are the same number of links and  $n_1 = n_2 = n$ , then  $m$  is a minimum of at least  $3 * n - 1$ .

179. (previously presented): The network of claim 174,  
wherein each of said input switches, or each of said output switches, or each of  
25 said middle switches further recursively comprise one or more networks.

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180. (previously presented): A network having a plurality of multicast connections, said network comprising:
- an input stage comprising  $r_1$  input switches and  $n_1$  inlet links for each of said  $r_1$  input switches, and  $N_1 = n_1 * r_1$ ;
  - 5 an output stage comprising  $r_2$  output switches and  $n_2$  outlet links for each of said  $r_2$  output switches, and  $N_2 = n_2 * r_2$ ; and
  - a middle stage comprising  $m$  middle switches, and each middle switch comprising at least one link connected to each input switch for a total of at least  $r_1$  first internal links; each middle switch further comprising at least one link connected to at
  - 10 most  $d$  said output switches for a total of at least  $d$  second internal links, wherein  $1 \leq d \leq r_2$ ,
- said network further is always capable of setting up said connection by never changing path of a previously set up multicast connection, and the network is hereinafter “strictly nonblocking network”, where  $m$  is a minimum of at least  $3 * n_1 + n_2 - 1$ .
- 15 181. (previously presented): The network of claim 180 wherein each multicast connection from an inlet link passes through at most three middle switches, and said multicast connection further passes a plurality of outlet links from said at most three middle switches.
182. (previously presented): The network of claim 180 comprising a controller in
- 20 communication with said input, output and middle stages to set up said multicast connection.
183. (previously presented): The network of claim 180 wherein said  $r_1$  input switches and  $r_2$  output switches are the same number of switches.
184. (previously presented): The network of claim 180 wherein said  $n_1$  inlet links and  $n_2$
- 25 outlet links are the same number of links and  $n_1 = n_2 = n$ , then  $m$  is a minimum of at least  $4 * n - 1$ .

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185. (previously presented): The network of claim 180 ,  
wherein each of said input switches, or each of said output switches, or each of  
said middle switches further recursively comprise one or more networks.

186. (previously presented): A network having a plurality of multicast connections, said  
5 network comprising:

an input stage comprising  $r_1$  input switches and  $n_1$  inlet links for each of said  $r_1$   
input switches, and  $N_1 = n_1 * r_1$ ;

an output stage comprising  $r_2$  output switches and  $n_2$  outlet links for each of said  
 $r_2$  output switches, and  $N_2 = n_2 * r_2$ ; and

10 a middle stage comprising  $m$  middle switches, and each middle switch  
comprising at least one link connected to each input switch for a total of at least  $r_1$  first  
internal links; each middle switch further comprising at least one link connected to at  
most  $d$  output switches for a total of at least  $d$  second internal links, wherein  $1 \leq d \leq r_2$  ,  
for  $2 \leq x \leq r_2$  ,

15 said network further is always capable of setting up said connection by never  
changing path of a previously set up multicast connection, and the network is hereinafter  
“strictly nonblocking network”, where  $m \geq x * n_1 + n_2 - 1$  .

187. (previously presented): The network of claim 186 wherein each multicast  
connection from an inlet link passes through at most  $x$  middle switches, and said  
20 multicast connection further passes a plurality of outlet links from said at most  $x$  middle  
switches.

188. (previously presented): The network of claim 186 comprising a controller in  
communication with said input, output and middle stages to set up said multicast  
connection.

25 189. (previously presented): The network of claim 186 wherein said  $r_1$  input switches  
and  $r_2$  output switches are the same number of switches.

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190. (previously presented): The network of claim 186 wherein said  $n_1$  inlet links and  $n_2$  outlet links are the same number of links and  $n_1 = n_2 = n$ , then  $m \geq (x+1)*n$ .

191. (previously presented): The network of claim 186,  
wherein each of said input switches, or each of said output switches, or each of  
5 said middle switches further recursively comprise one or more networks.

192. (previously presented): A network comprising a plurality of input subnetworks, a plurality of middle subnetworks, and a plurality of output subnetworks, wherein at least one of said input subnetworks, said middle subnetworks and said output subnetworks recursively comprise:

10 an input stage comprising  $r_1$  input switches and  $n_1$  inlet links for each of said  $r_1$  input switches;

an output stage comprising  $r_2$  output switches and  $n_2$  outlet links for each of said  $r_2$  output switches; and

a middle stage, said middle stage comprising  $m$  middle switches, and each middle  
15 switch comprising at least one link (hereinafter "first internal link") connected to each input switch for a total of at least  $r_1$  first internal links, each middle switch further comprising at least one link (hereinafter "second internal link") connected to at most  $d$  said output switches for a total of at least  $d$  second internal links, wherein  $1 \leq d \leq r_2$ , and for  $x \leq 2$ ;

20 wherein each multicast connection from an inlet link passes through at most  $x$  middle switches, and said multicast connection further passes to a plurality of outlet links from said at most  $x$  middle switches.

193. (new): A method of setting up a multicast connection through a three-stage network, said multicast connection comprising a plurality of output switches having destination  
25 outlet links, said method comprising:

fanning out only one or two times in an initial stage,

and fanning out any number of times in each of the remaining stages,

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wherein said three-stage network includes said remaining stages and said initial stage.

194. (new): The method of claim 193 further comprising:  
repeating said acts of fanning out with a plurality of portions of each of said  
5 stages.

195. (new): The method of claim 193 further comprising:  
recursively performing said act of fanning out.

196. (new): The method of claim 193 wherein:  
a remaining stage immediately following said initial stage comprises internal links  
10 that are at least two times the total number of inlet links of said initial stage.

197. (new): The method of claim 193 wherein:  
said initial stage comprises a plurality of first switches, and a plurality of inlet  
links connected to each said first switch; and  
a remaining stage immediately following said initial stage comprises a plurality of  
15 second switches, that are at least double the number of inlet links of each first switch and  
each second switch comprises a plurality of internal links at least equal in number to the  
number of first switches in said initial stage.

198. (new): A method of setting up a multicast connection through a three-stage network,  
said multicast connection comprising a plurality of output switches having destination  
20 outlet links, said method comprising:  
fanning out at most three times in an initial stage,  
and fanning out any number of times in each of the remaining stages,  
wherein said three-stage network includes said remaining stages and said initial  
stage.

199. (new): The method of claim 198 further comprising:  
repeating said acts of fanning out with a plurality of portions of each said stages.

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200. (new): The method of claim 198 further comprising:  
recursively performing said act of fanning out.
201. (new): The method of claim 198 wherein:  
a remaining stage immediately following said initial stage comprises internal links  
5 that are at least three times the total number of inlet links of said initial stage.
202. (new): The method of claim 198 wherein:  
said initial stage comprises a plurality of first switches, and plurality of inlet links  
connected to each said first switch; and  
a remaining stage immediately following said initial stage comprises a plurality of  
10 second switches, that are at least three times the number of inlet links of each first switch  
and each second switch comprises a plurality of first internal links at least equal in  
number to the number of first switches in said initial stage.  
said multicast connections having a fan-out of one or more in said middle stage.
203. (new): A method of setting up a multicast connection through a three-stage network,  
15 for  $x \geq 2$ , said multicast connection comprising a plurality of output switches having  
destination outlet links, said method comprising:  
fanning out at most  $x$  times in an initial stage,  
and fanning out any number of times in each of the remaining stages,  
wherein said three-stage network includes said remaining stages and said initial  
20 stage.
204. (new): The method of claim 203 further comprising:  
repeating said acts of fanning out with a plurality of portions of each of said  
stages.
205. (new): The method of claim 203 further comprising:  
25 recursively performing said act of fanning out.
206. (new): The method of claim 203 wherein:

AMENDMENT B, Contd.

a remaining stage immediately following said initial stage comprises internal links that are at least  $x$  times the total number of inlet links of said initial stage.

207. (new): The method of claim 203 wherein:

5       said initial stage comprises a plurality of first switches, and plurality of inlet links connected to each said first switch; and

      a remaining stage immediately following said initial stage comprises a plurality of second switches that are at least  $x$  times the number of inlet links of each first switch and each second switch comprises a plurality of first internal links at least equal in number to the number of first switches in said initial stage.

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